SYSTEMS SAFETY AND COLLISION INVESTIGATION

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SoRSA and CIHT East Midlands Road Safety Workshop

6th February 2025

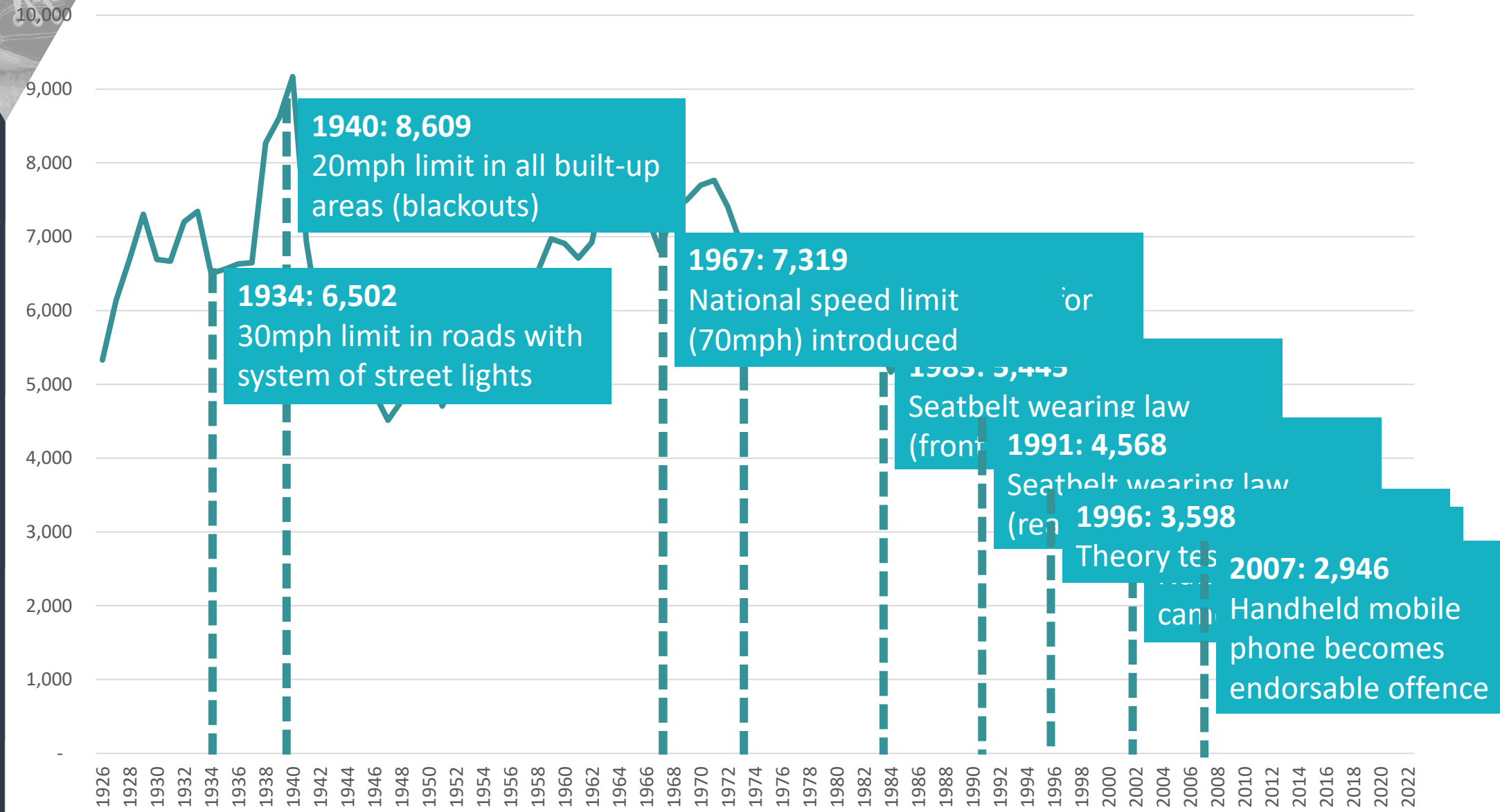
AGENDA

- History of road safety management
- System-based approaches
- Application of STAMP
  - Mapping actors
  - Collision investigation
  - Making recommendations

100+ YEARS OF ROAD SAFETY MANAGEMENT

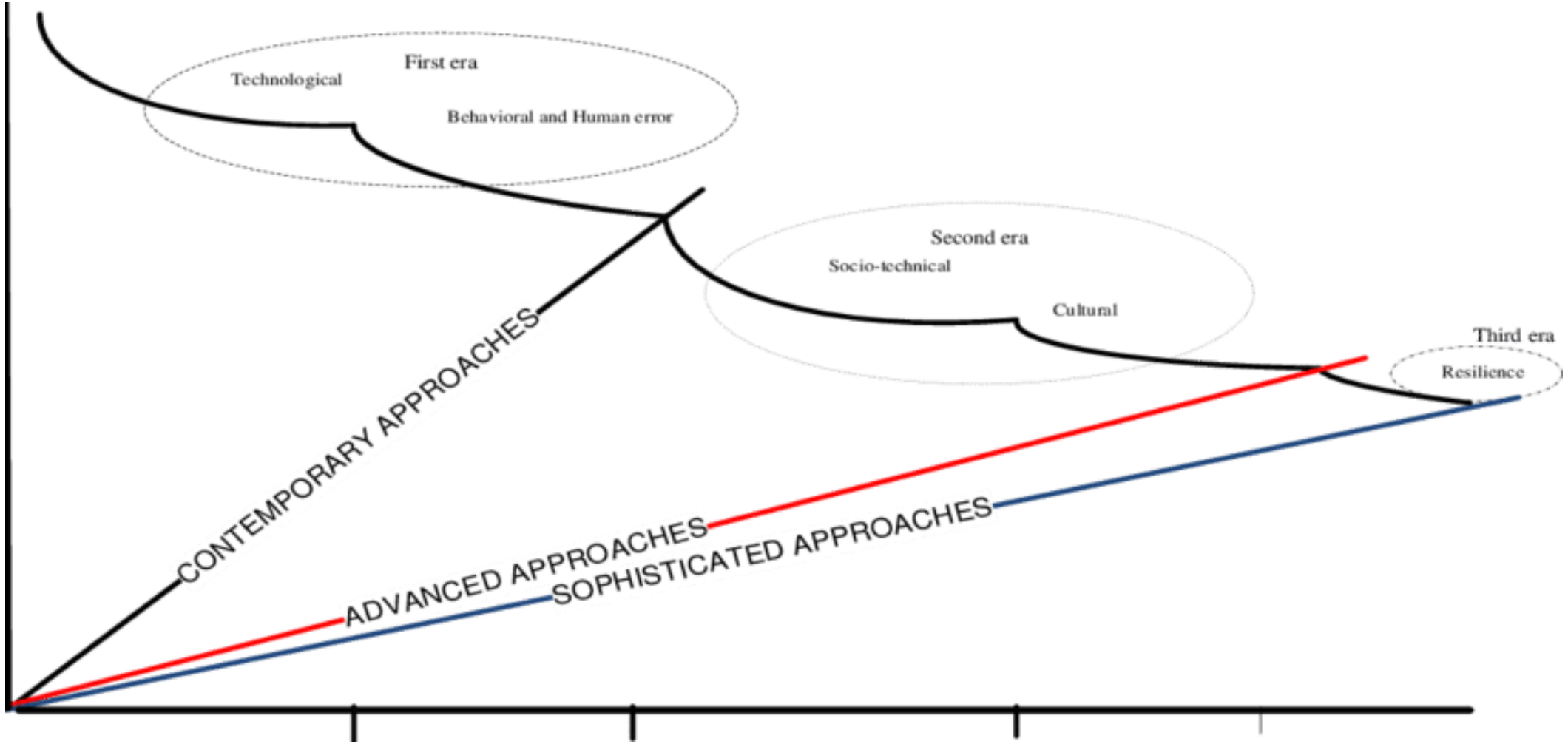
- What have we learned?

Road Deaths in Great Britain



FIVE AGES AND THREE ERAS OF SAFETY

- (Pillay *et al.*, 2010)



RESEARCH GAP

- Person-based vs system-based approaches

Person-based approach

- Human error is the cause of all incidents
- We can make things safer by changing people so they “do it safer” or by removing people who make errors
- Focus on immediate causes
- Focus on attributing blame

System-based approach

- Incidents are the product of failures in the system
- Safety is an emergent property of a complex combination of socio-technical factors
- Focus on interactions between system factors at all levels
- Focus on explaining why things happened

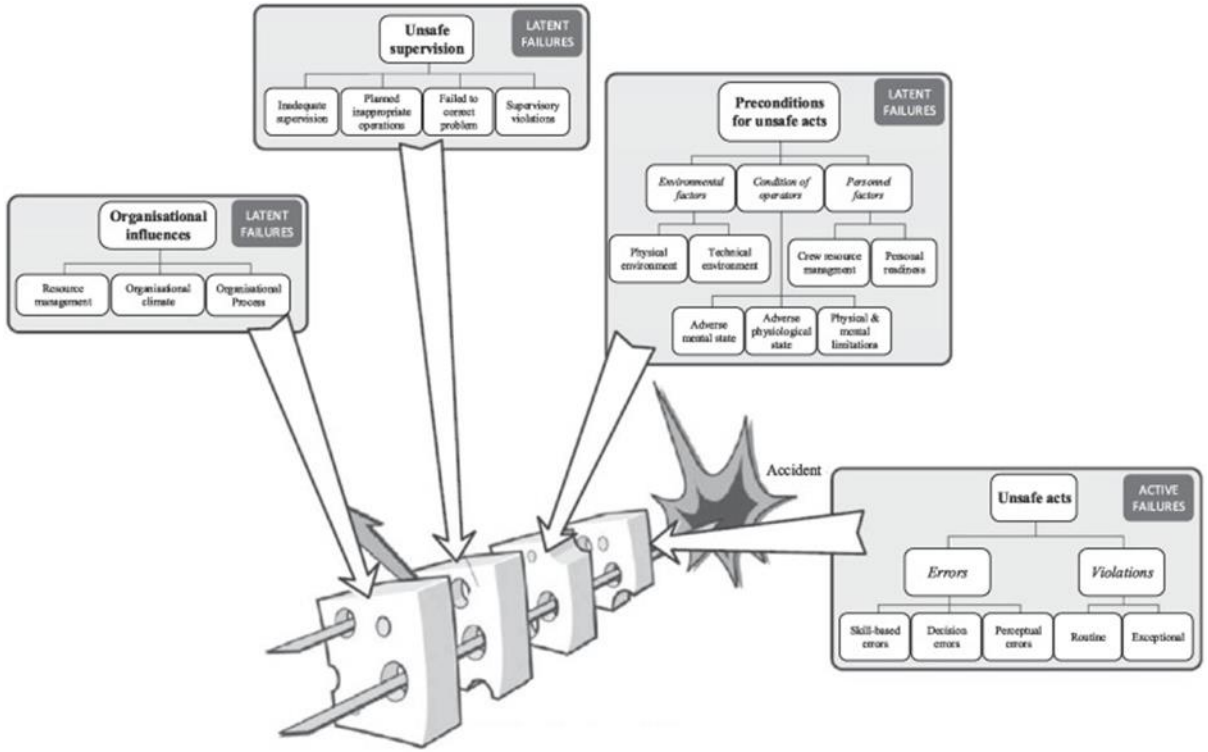
WHAT IS A SYSTEM?

- A system is a product of component parts which together provide an outcome that no individual part can perform on its own

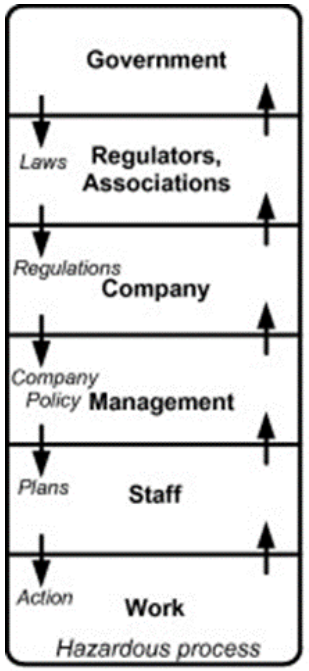
SYSTEM-BASED APPROACHES IN ROAD SAFETY

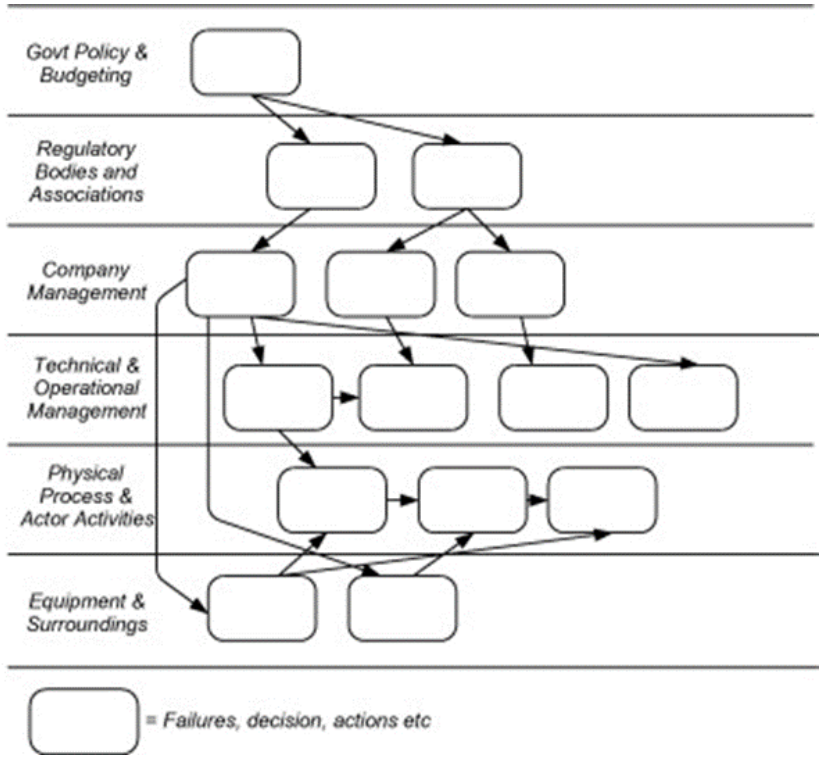
- While practice reflects person-based approaches, four system-based methods have been used in research

1. The Human Factors Analysis and Classification System (HFACS) (Shappell and Wiegmann, 2001)



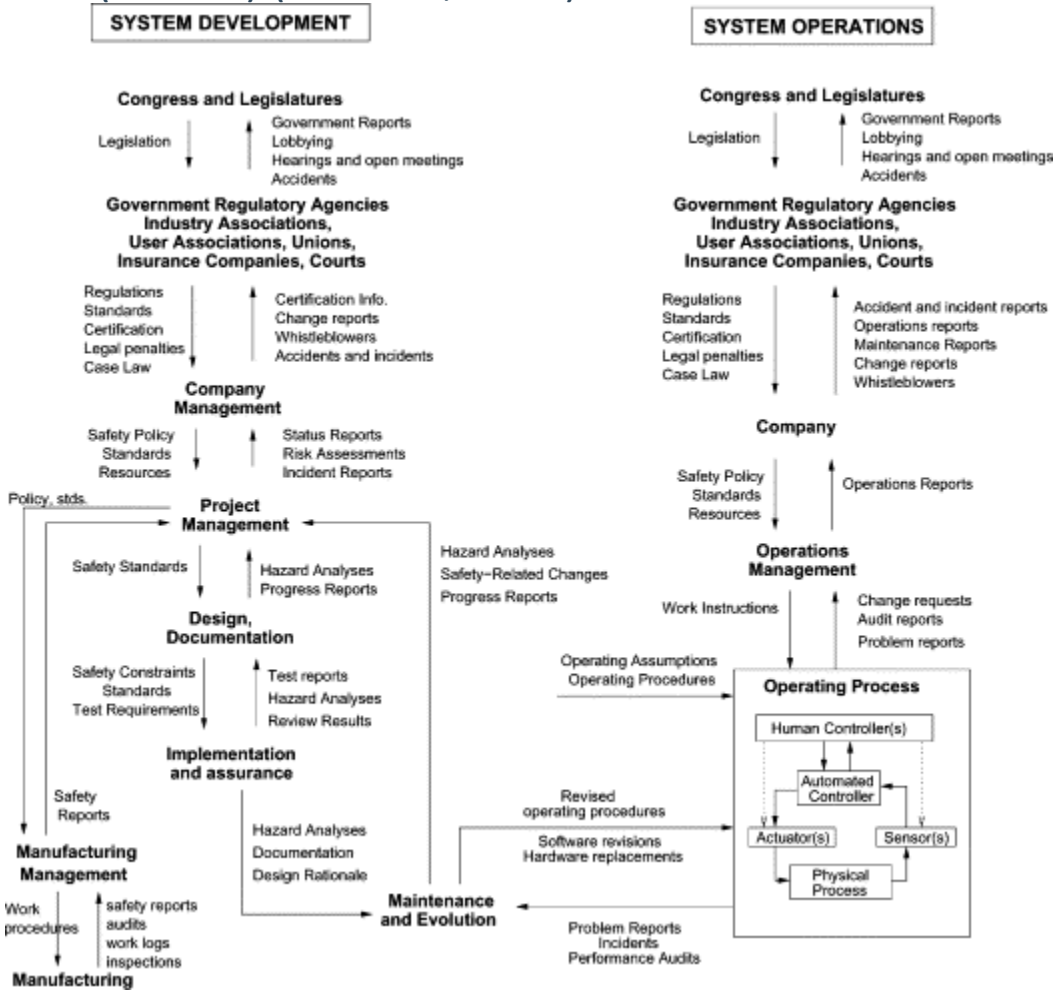
2. AcciMap (Svedung and Rasmussen, 2002)



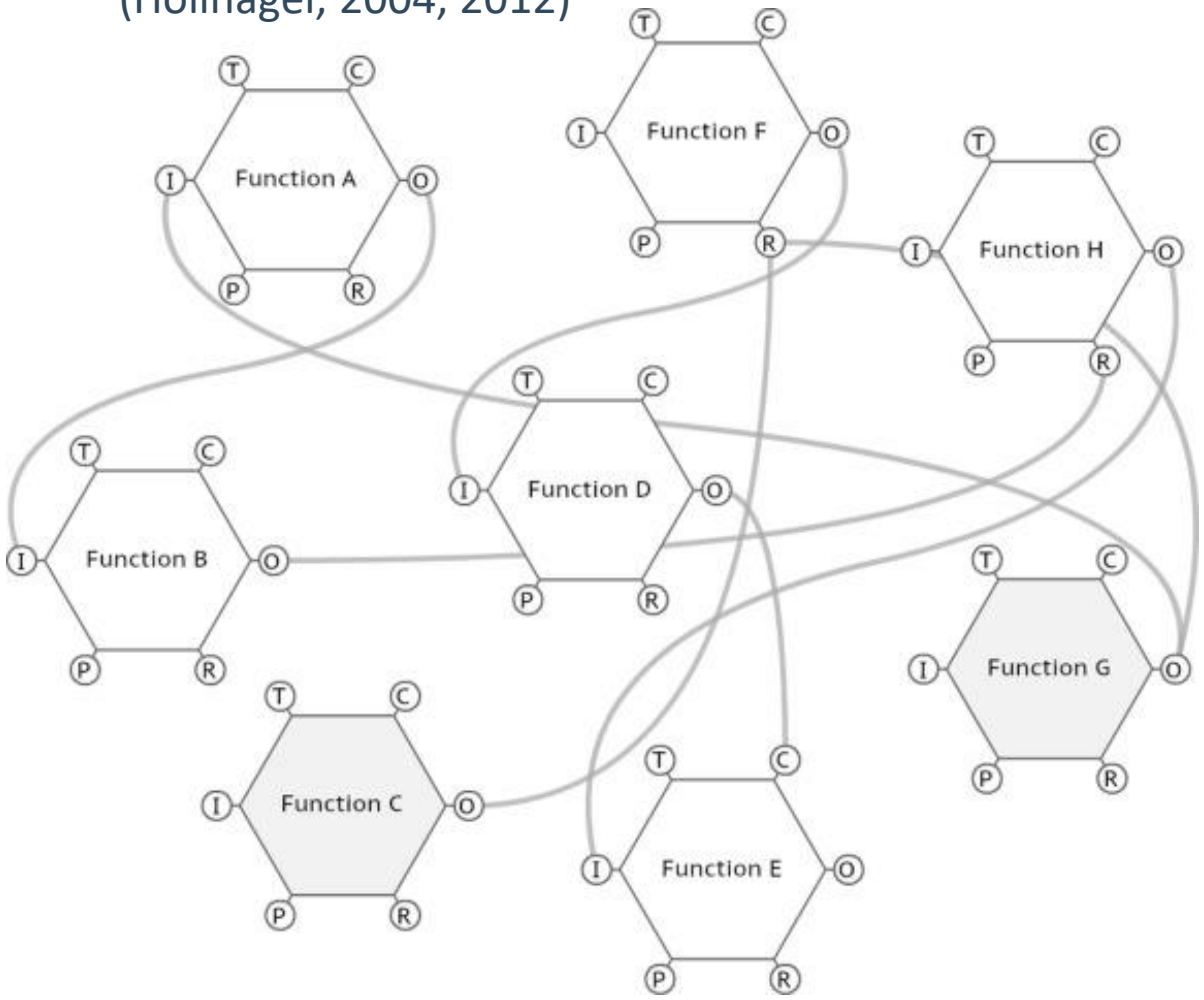


SYSTEM-BASED APPROACHES IN ROAD SAFETY

3. Systems-Theoretic Accident Model and Processes (STAMP) (Leveson, 2004)

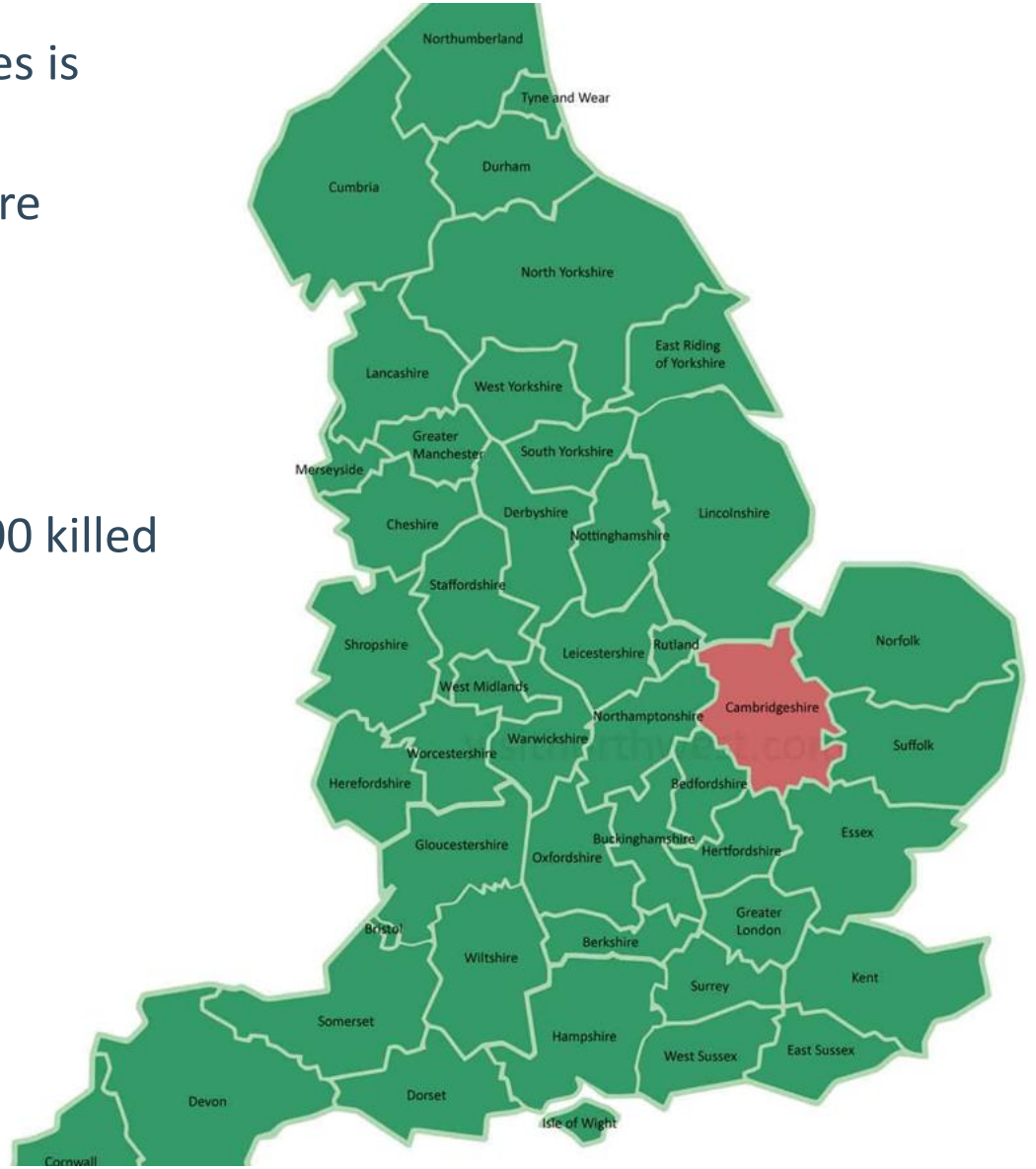


4. Functional Resonance Analysis Method (FRAM) (Hollnagel, 2004, 2012)



MUNICIPAL AREA OF CAMBRIDGESHIRE

- In the UK decision-making relating to road safety priorities is devolved to a local level
- My work focused on the municipal area of Cambridgeshire
- Area 340,000 hectares
- Approx. 6000 km road
- Population approx. 900,000
- Between 2012 and 2021 on Cambridgeshire's roads >4500 killed or seriously injured - 365 killed approx. 1 every 10 days



USING STAMP TO IMPLEMENT A SYSTEM-BASED APPROACH

- Why STAMP?

Pros

- Covers all system levels (Stanton *et al.*, 2019)
- Suitable for road traffic collision analysis (Stanton *et al.*, 2019)
- Advantages in capturing decision-making and the context in which decisions are made (Salmon, Cornelissen and Trotter, 2012; Goncalves Filho, Jun and Waterson, 2019)

Cons

- Considered time consuming and complex (Stanton *et al.*, 2019)
- Based on causality as opposed to performance variability (Ma *et al.*, 2021)

MAPPING THE ACTORS INVOLVED

International Context

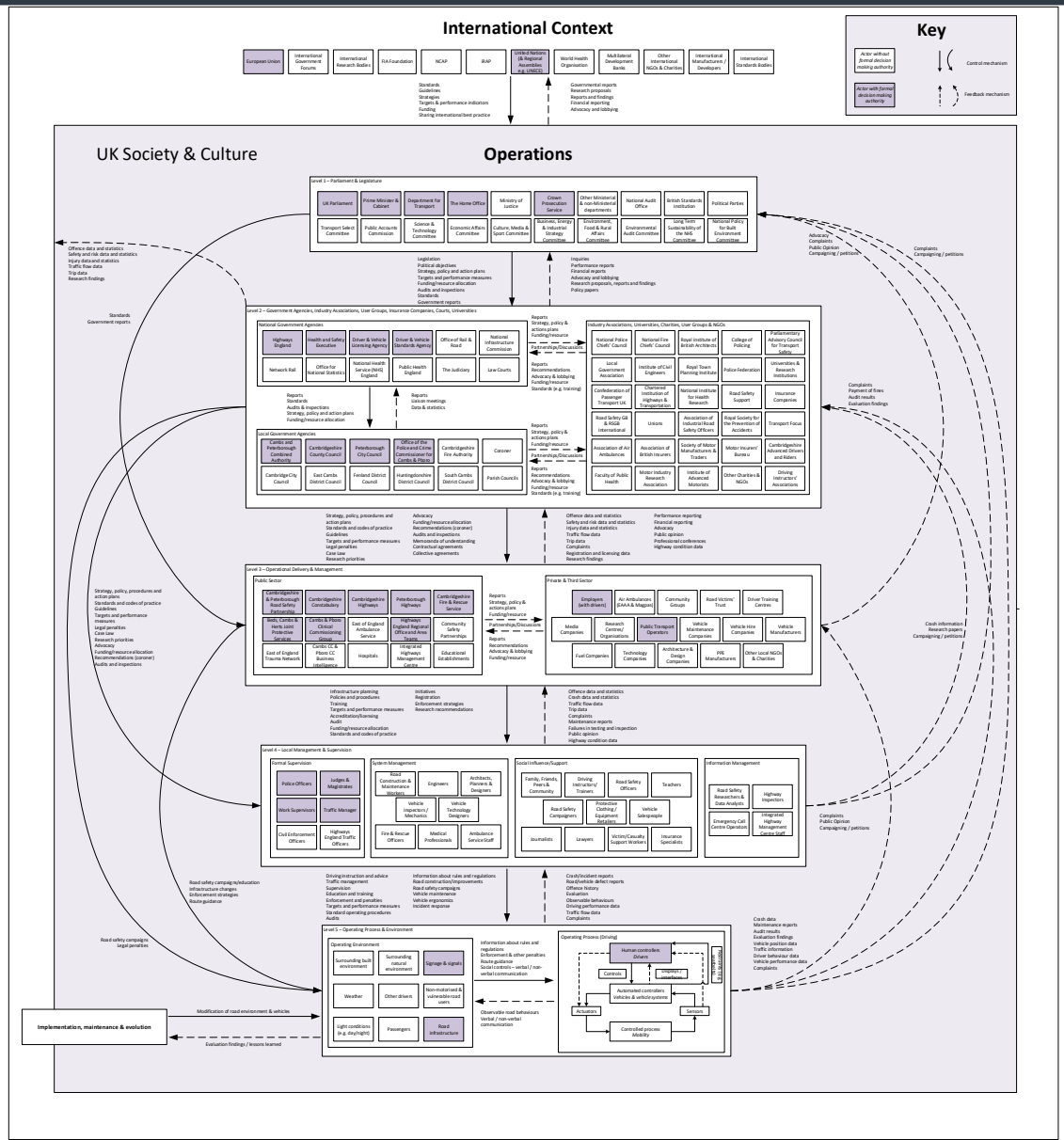
Level 1 – Parliament & Legislature

Level 2 – Government Agencies, Universities, Industry Associations, User Groups etc.

Level 3 – Operational Delivery & Management

Level 4 – Local Management & Supervision

Level 5 – Road Users, Vehicles and the Road Environment



KEY FINDINGS

The key findings from mapping the control structure were:

- Most mechanisms are influencing rather than controlling, but this means the formal controls are very important
- Most actors with formal decision-making responsibility are public bodies or elected politicians
- Interrelationships between actors at the same level were represented
- Convergence of professional advice and public perception in influencing decision-making at Level 2 and 3
- A baseline structure prior to Brexit providing a platform for future analysis of what has changed

INTERVIEWS WITH KEY ACTORS

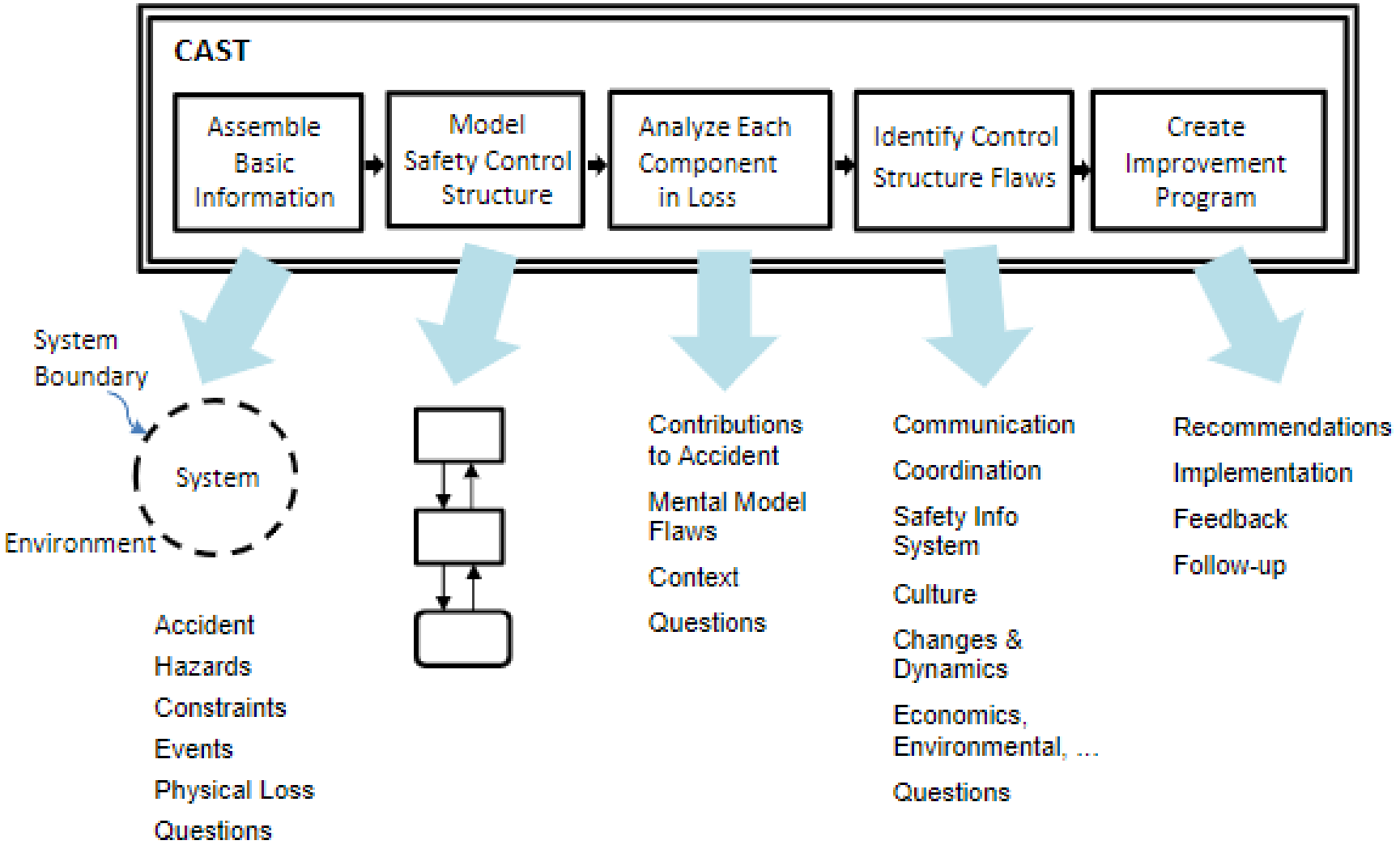
The key findings from the interviews were:

- Reinforced that the predominant approach is person-based
- There was an emerging understanding of Vision Zero / Safe System Approach
- Reinforced the importance of interrelationships between actors in decision-making
- Identified discipline-based silo working
- Public perception holds the balance over research evidence in contentious issues
- Ethical concerns around lack of evidence being used and a need to “be seen to do something”
- Funding is a key facilitator (or barrier)

COLLISION INVESTIGATION USING STAMP-CAST

- 10 fatal collisions chosen at random from the 85 that occurred 2018-2020
- Police collision file used to undertake analysis
- Analysis of one collision reviewed by supervisor and a police collision investigator

USING CAST


CAST
Assemble Basic Information
Model Safety Control Structure
Analyze Each Component in Loss
Identify Control Structure Flaws
Create Improvement Program
System Boundary
System
Environment
Accident
Hazards
Constraints
Events
Physical Loss
Questions
Contributions to Accident
Mental Model Flaws
Context
Questions
Communication
Coordination
Safety Info System
Culture
Changes & Dynamics
Economics, Environmental, ...
Questions
Recommendations
Implementation
Feedback
Follow-up

10 SYSTEM HAZARDS IDENTIFIED

(Note: unless stated as a 'motor vehicle' the term 'vehicle' is used to describe all mechanically propelled vehicles on the road i.e., including bicycles)

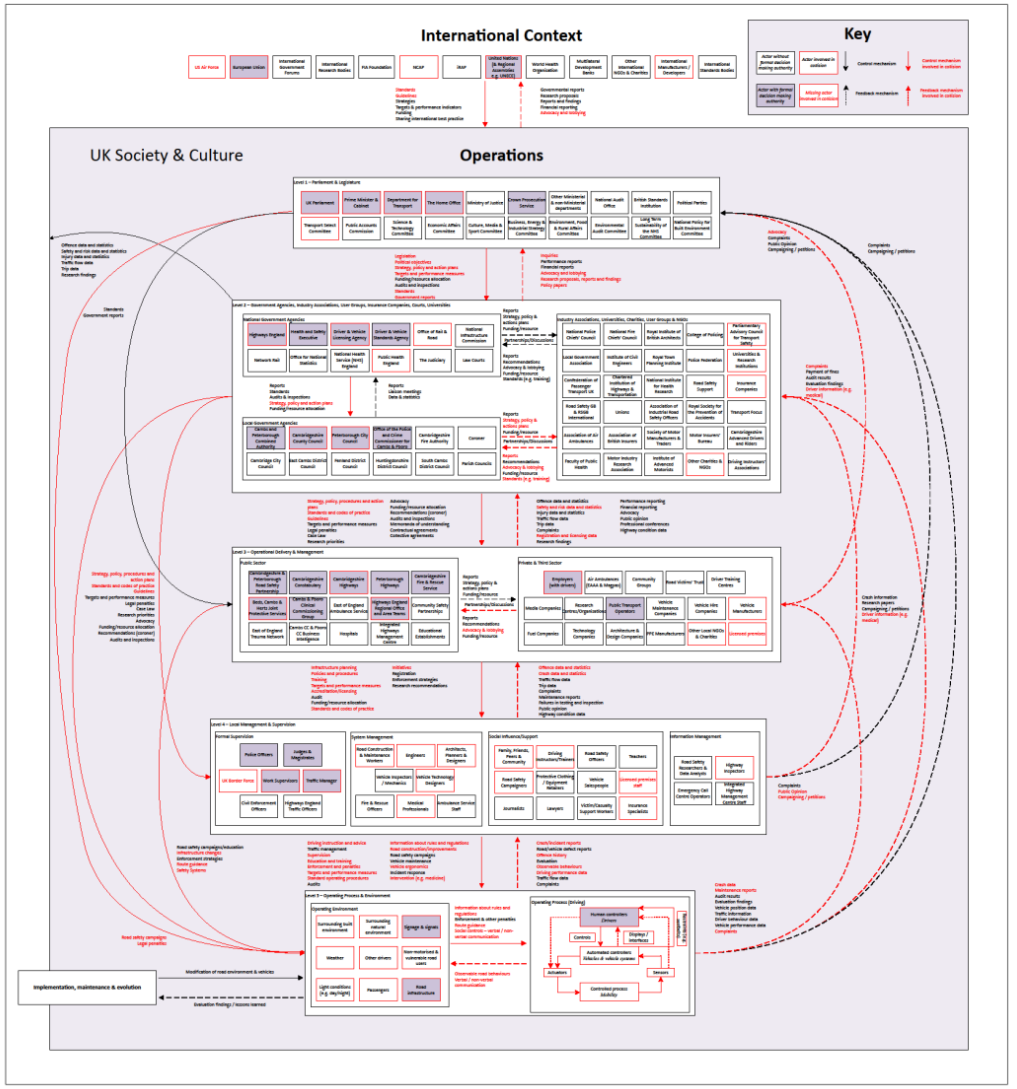
1. A vehicle collides with a pedestrian
2. A motor vehicle collides with a bicycle
3. A vehicle collides with an animal or ridden horse
4. A vehicle leaves the road (run-off road collision)
5. A head on collision between vehicles (on-coming traffic)
6. A rear-end / sideswipe collision between vehicles (same-direction traffic)
7. A collision between vehicles at a junction (no turning)
8. A collision between vehicles at a junction (turning)
9. A road user comes into conflict with a train at a rail crossing
10. The public are unable to safely access services, education, or employment

FREQUENCY OF SYSTEM HAZARDS ACROSS ALL TEN COLLISIONS

System hazard	Case										Frequency in overall dataset (n=85)
	5	7	22	41	51	58	64	67	77	83	
1. A vehicle collides with a pedestrian			*								9 (11%)
2. A motor vehicle collides with a bicycle							*			*	7 (8%)
3. A vehicle collides with an animal or ridden horse											0 (0%)
4. A vehicle leaves the road (run-off road collision)	*			*	*	*		*	*		36 (42%)
5. A head-on collision between vehicles (on-coming traffic)								*			25 (29%)
6. A rear-end / sideswipe collision between vehicles (same-direction traffic)							*				14 (16%)
7. A collision between vehicles at a junction (no turning)							*				11 (13%)
8. A collision between vehicles at a junction (turning)		*									13 (15%)
9. A road user comes into conflict with a train at a rail crossing											0 (0%)
10. The public are unable to safely access services, education, or employment			*	*	*		*	*	*	*	n/a

HIGHEST FREQUENCY FACTORS IDENTIFIED

Factor	Actor	No. cases
Design and speed limit guidance are not adequate in protecting road users from the conflicts that will occur.	Government	8
Speed limits set above safe speeds for conflicts that occur.	Local Highway Authority	7
The speed of the road is above the recognised 'safe speed' for the type of conflicts that could occur between users.	Physical controls	6
Inadequate protection of road users from roadside hazards or containment of vehicle within the highway.	Local Highway Authority	5
There was inadequate protection from collision with hazardous roadside objects.	Physical controls	4
Travelling too fast (either exceeding the speed limit or too fast for the conditions)	Driver	4
Driver had no documentation or used fraudulent documentation to access the system.	Driver	4
Work to tackle the known issue of speeding.	Government	4



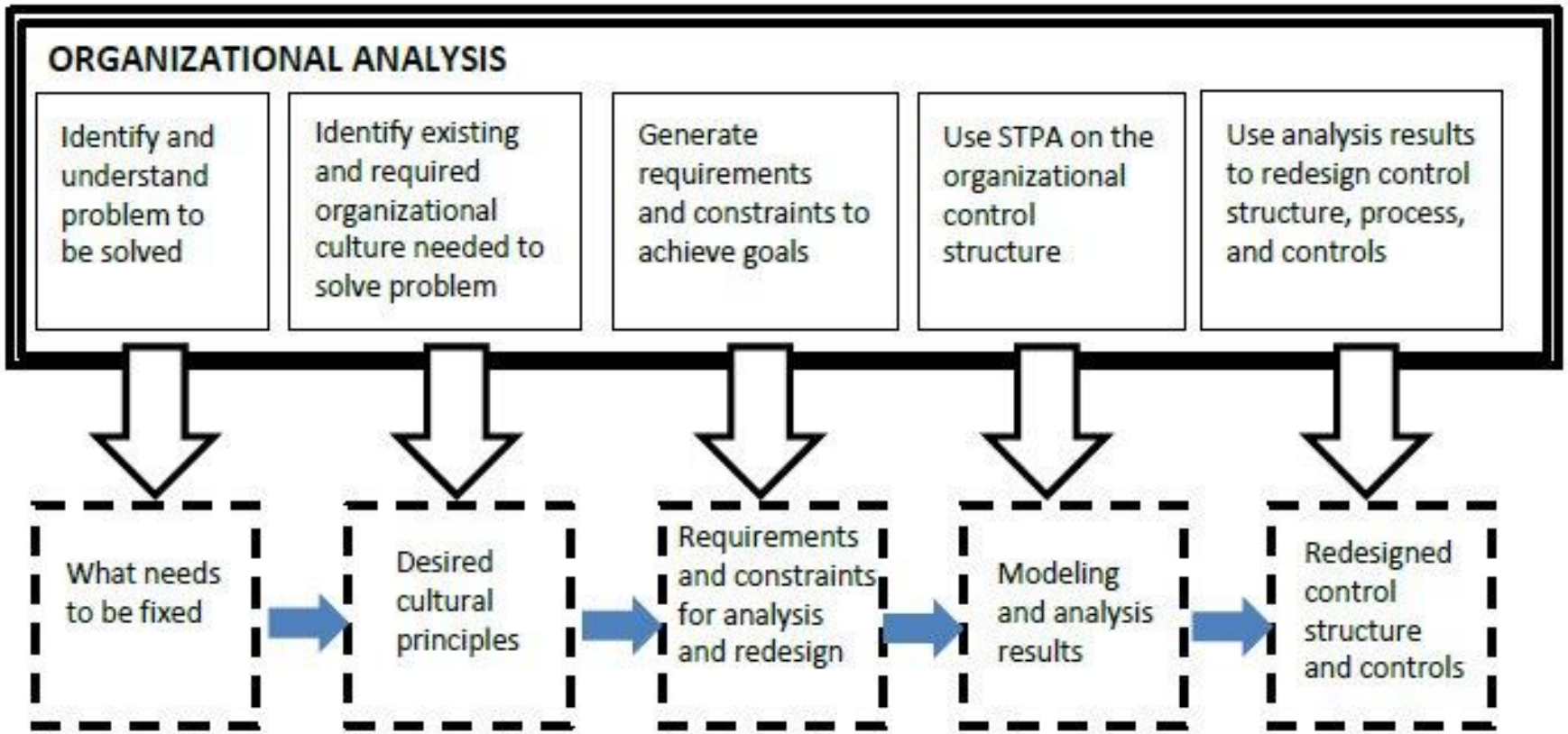
SUMMARY OF RECOMMENDATIONS FROM CAST ANALYSIS

1. Review of road hierarchy classification and associated design principles in relation to speed, protection of vulnerable road users, consistency and sensitivity to human error.
2. Review of processes for maintenance, asset management and diversion routes.
3. Consolidation of funding and resources nationally to provide evidence-led and robustly evaluated road safety information campaigns, maximising the effectiveness of limited resources. This should focus on the following topics highlighted from the investigations: close following; speed (including developing support for lower limits); the importance of vulnerable road users being visible at night; cycle helmets; peer influence.
4. Research or further investigation into the suitability of training for drivers in the gig economy and incidents involving drunk pedestrians.

SUMMARY OF RECOMMENDATIONS FROM CAST ANALYSIS

5. Adoption of system-based as opposed to person-based views of accident causation within transport policy to help shift the focus away from individual blame to wider learning and system improvement and reduce reductionist approaches to intervention design.
6. Increased visible enforcement of road rules.
7. Prioritisation of funding for safety schemes.
8. Ensuring positive public engagement and public and political support for new ways of working in line with system-based approaches.
9. Incentivise scrapping of older, less-safe vehicles with support to purchase new vehicles or vouchers towards sustainable travel e.g. public transport.
10. Continue development of industry best practice and assessment of cultural maturity.

ORGANISATIONAL ANALYSIS USING STPA



ORGANISATIONAL ANALYSIS USING STPA

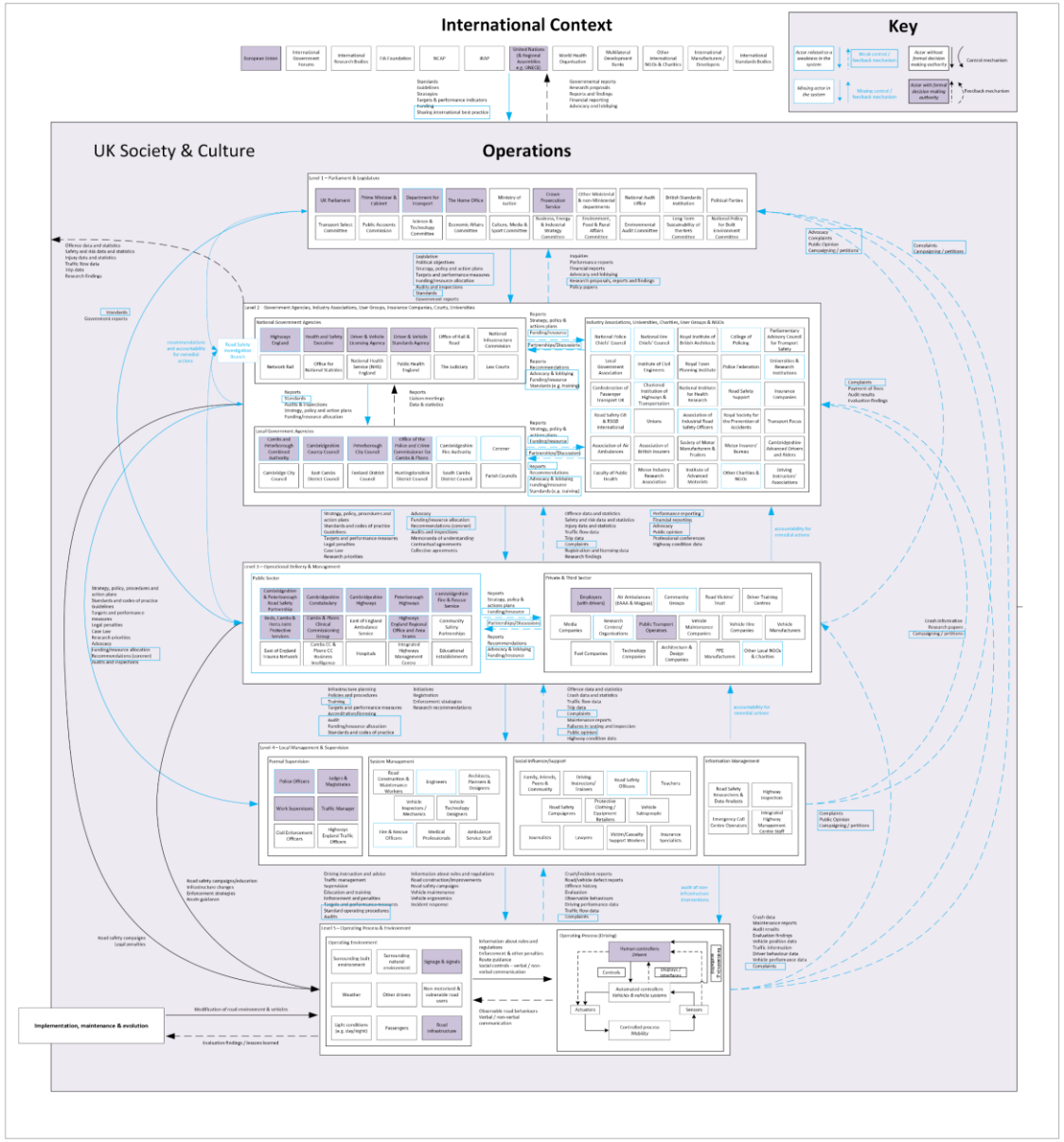
Summary of issues from interviews:

1. A reliance on person-based approaches leading to the prioritisation of reductionist, individual road user behaviour-centred interventions, some of which are known to have caused harm.
2. Silo working across disciplines within the industry.
3. Links at a local level between subject-matter experts and political decision-makers are inconsistent and based on individual relationships.
4. The weight given to public perception within decision-making, particularly at a local level, reinforces the reductionist, individual road user behaviour-centred approaches, particularly education and training.
5. Current economic appraisal calculations are not well suited to proactive, system-based approaches.
6. Limited resources (staff and funding) to implement interventions.

ORGANISATIONAL ANALYSIS USING STPA

Weaknesses in / opportunities to improve the system

1. Learning from incidents
2. Quality intervention (evidence-based practice)
3. Prioritising safety
4. Public engagement
5. Collaboration
6. Workforce development



RECOMMENDATIONS

1. **The Department for Transport should complete the establishment of a road safety investigation branch** to undertake system-based investigations into road traffic collisions and associated incidents. This should also be supplemented with system-based investigation at a highway authority level e.g., by Cambridgeshire County Council for collisions on their network.
2. **The Department for Transport should lead development of clear guidance for practitioners in developing quality, evidence-based road safety interventions and work with National Highways to review the road design standards and guidance to reflect safe conflict speeds.** This should be accompanied by an audit process for non-infrastructure interventions, mirroring the road safety audit requirement for infrastructure schemes.
3. **Funding bodies should incentivise partnership working and system-based approaches in their grant criteria and prioritise interventions with the greatest safety benefits, not just the greatest BCR.**
4. **Local partnerships should develop collaborative strategies based on system safety principles and community engagement.**
5. **Government agencies and industry bodies should collaborate to develop a training framework covering the breadth of the road safety industry.**

REFERENCES

- Hollnagel, E. (2004) *Barriers and Accident Prevention*. Aldershot: Ashgate Publishing Ltd.
- Hollnagel, E. (2012) *FRAM, the Functional Resonance Analysis Method: Modelling Complex Socio-technical Systems*. Ashgate Publishing, Ltd.
- Leveson, N. (2004) 'A new accident model for engineering safer systems', *Safety Science*, 42(4), pp. 237–270. Available at: https://doi.org/10.1016/S0925-7535(03)00047-X.
- Leveson, N. (2019) 'CAST Handbook: How to learn more from incidents and accidents'. MIT press.
- Leveson, N. (2020) 'Safety III: A systems approach to safety and resilience'. Boston, MA: MIT Engineering Systems Lab.
- Leveson, N.G. and Thomas, J.P. (2018) 'STPA handbook'. Cambridge, MA: MIT press.
- Pillay, M., Borys, D., Else, D. and Tuck, M. (2010) 'Safety Culture and Resilience Engineering – Exploring Theory and Application in Improving Gold Mining Safety', in *Gravity Gold Conference*. Ballerat, VIC, pp. 21–22.
- Shappell, S.A. and Wiegmann, D.A. (2001) 'Applying Reason: The human factors analysis and classification system (HFACS).', *Human Factors and Aerospace Safety*.
- Svedung, I. and Rasmussen, J. (2002) 'Graphic representation of accident scenarios: mapping system structure and the causation of accidents', *Safety Science*, 40(5), pp. 397–417. Available at: https://doi.org/10.1016/s0925-7535(00)00036-9.
- **Staton, M., Barnes, J., Morris, A. and Waterson, P. (2022) '"Over to you": using a STAMP control structure analysis to probe deeper into the control of UK road safety at a municipal level – the case of Cambridgeshire', *Ergonomics*, 65(3), pp. 429–444. Available at: https://doi.org/10.1080/00140139.2021.1968033.**
- **Staton, M., Barnes, J., Morris, A., & Waterson, P. (2023). Learning not blaming: Investigating ten fatal road traffic collisions using STAMP-CAST. Transportation research interdisciplinary perspectives, 21, 100912. https://doi.org/10.1016/j.trip.2023.100912**

THANK YOU

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